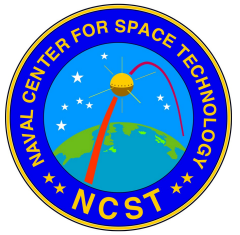


FAME
SPACECRAFT BUS
THERMAL CONTROL SUBSYSTEM
(TCS)
August 16, 2001

Robert Baldauff
Naval Research Laboratory
Code 8221

Outline

- Descopes
- Requirements
  - Mission
  - Derived
  - TCS Levied
- Results of Descope
- Preliminary Design
- Preliminary Analysis
- Forward Work
- Trade Studies
- Schedule
- Issues/Concerns

Descopes

- Major
  - Active Temperature Control
  - Bus Radiator
  - Deployed Solar Panels
  - Thermal Thrusters
  - Electronics Deck Face Sheet
    - Composite to Aluminum
- Minor
  - Sun Angle to Spin Axis
    - From 45 to 35°

Mission Requirements

- Instrument Interface Temperature Control
  - Was:
    - »20 ± 2C
  - Is:
    - »0 to 40C TBR
- Result:
  - Hysteresis type heater circuit deleted.

Derived Requirements
(1 of 3)

- Instrument to Bus Radiation Interface
  - Was:
    - The view of the back of the deployed sun shield to the instrument shall be obstructed with MLI blankets.
  - Is:
    - Deleted
- Result:
  - New instrument design unaffected.
  - Bus TCS design simplified.

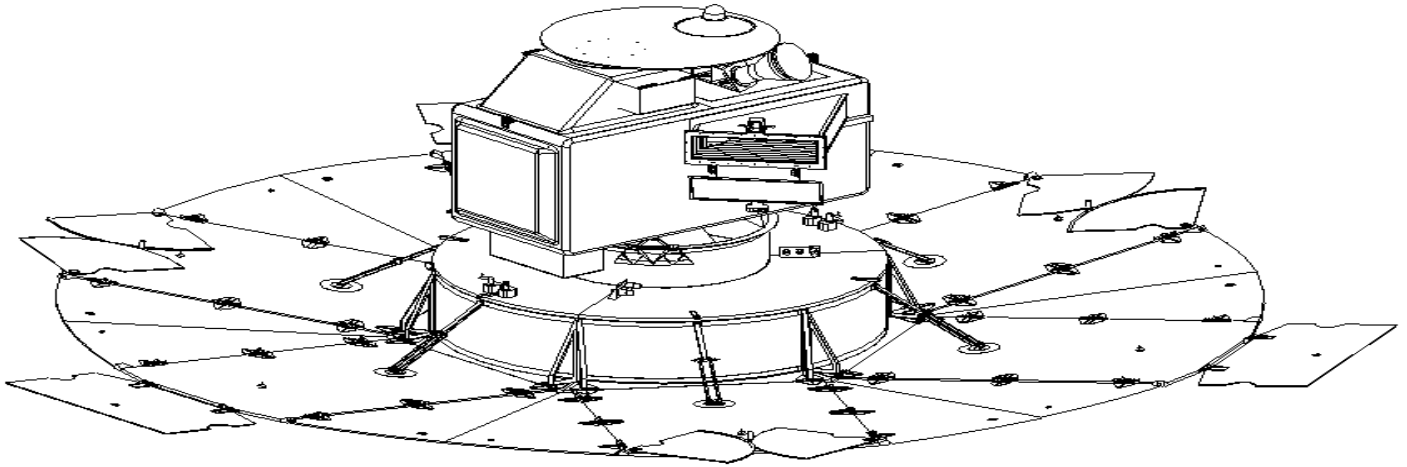
Derived Requirements
(2 of 3)

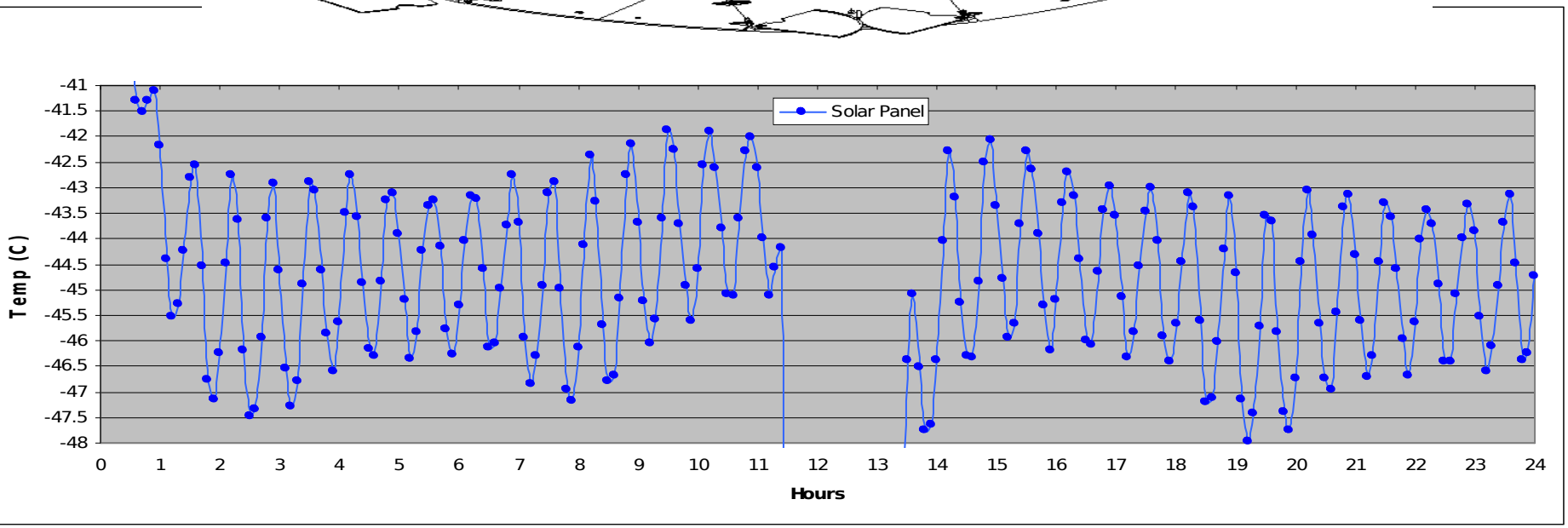
- Magnetometer Temperature Control
  - Was:
    - Tight temperature control required to dampen out effects of being mounted to the swept sun shield.
  - Is:
    - Deleted

- Result:
  - Hysteresis type heater circuit deleted.

Derived Requirements
(3 of 3)

- Magnetometer Temperature C[illegible]





TCS Levied Requirements

- Instrument Facing Bus Radiator
  - Instrument shall have view of 10ft^2 radiator with a temperature range of 0 to 40C.
- Initial analysis shows no significant impact to new instrument design. TBR

Results of Descope

(1 of 3)

- Reduced mass by 67 lbs.
- Reduced Budget ~500K.
- Reduced Labor.
- Reduced Mission Risk.

Results of Descope

(2 of 3)

- Cost Savings
  - Reduced Analysis time
    - Simplified Design
    - Less Interfaces
    - Less Mechanisms
  - Less Hardware
    - Heater Circuits
    - MLI Blankets
    - Documentation
  - Reduced Silver Teflon Tape
    - Labor Intensive

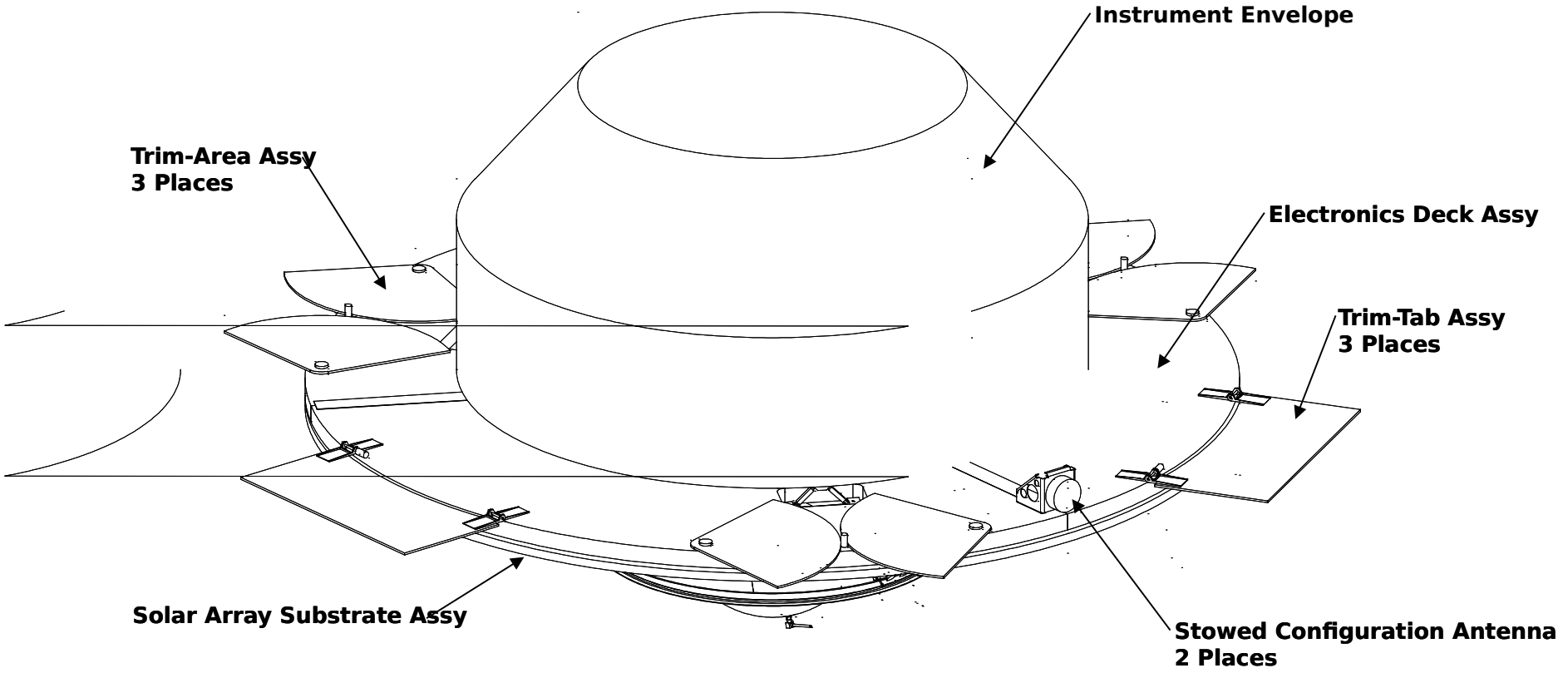
Results of Descope

(3 of 3)

- Mass Savings
  - Sun shield surface area reduced ~ 200ft^2.
    - MLI blankets
    - Silver Teflon Tape
  - Heater circuits reduced (motors, e-deck)
    - Heaters
    - Thermostats

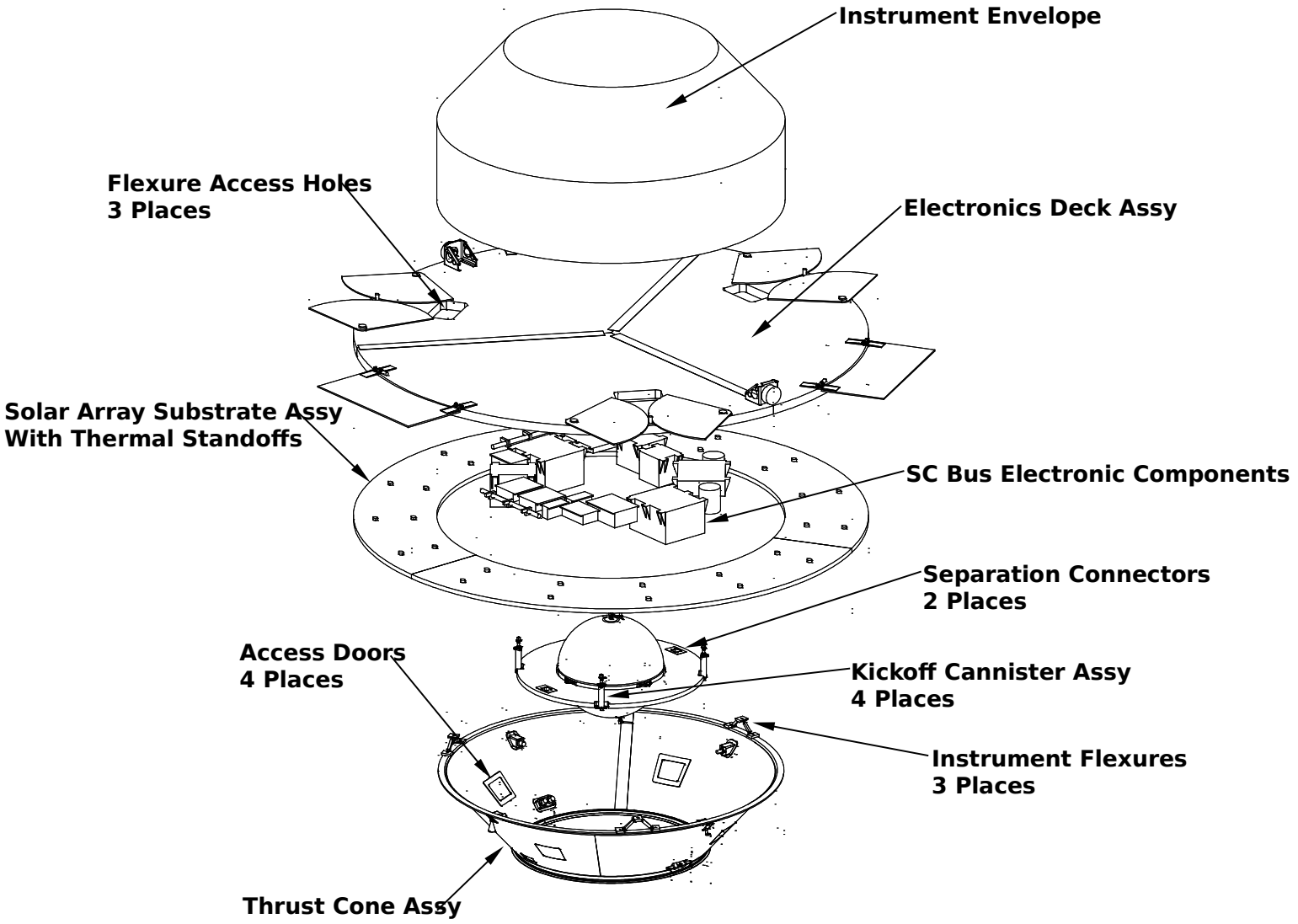
Preliminary Design

(1 of 4)



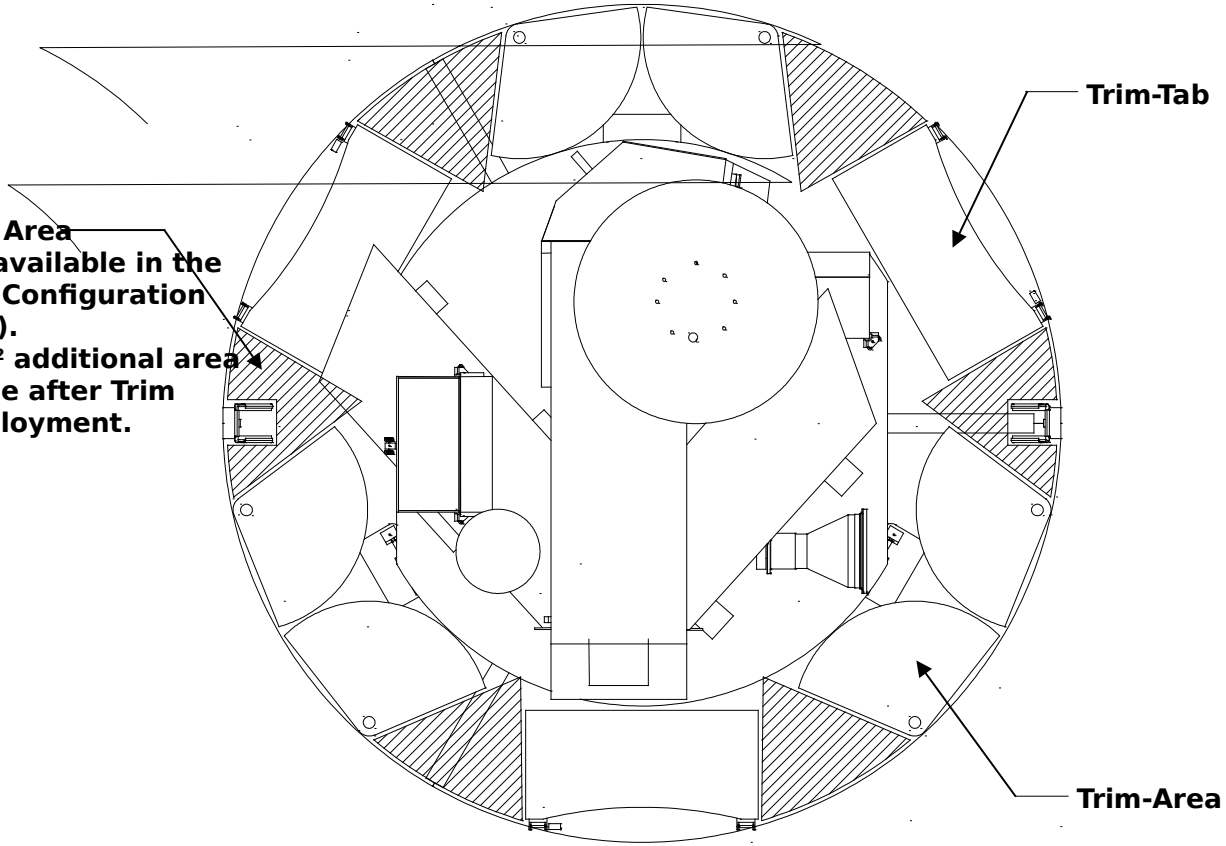
Preliminary Design

(2 of 4)



Preliminary Design

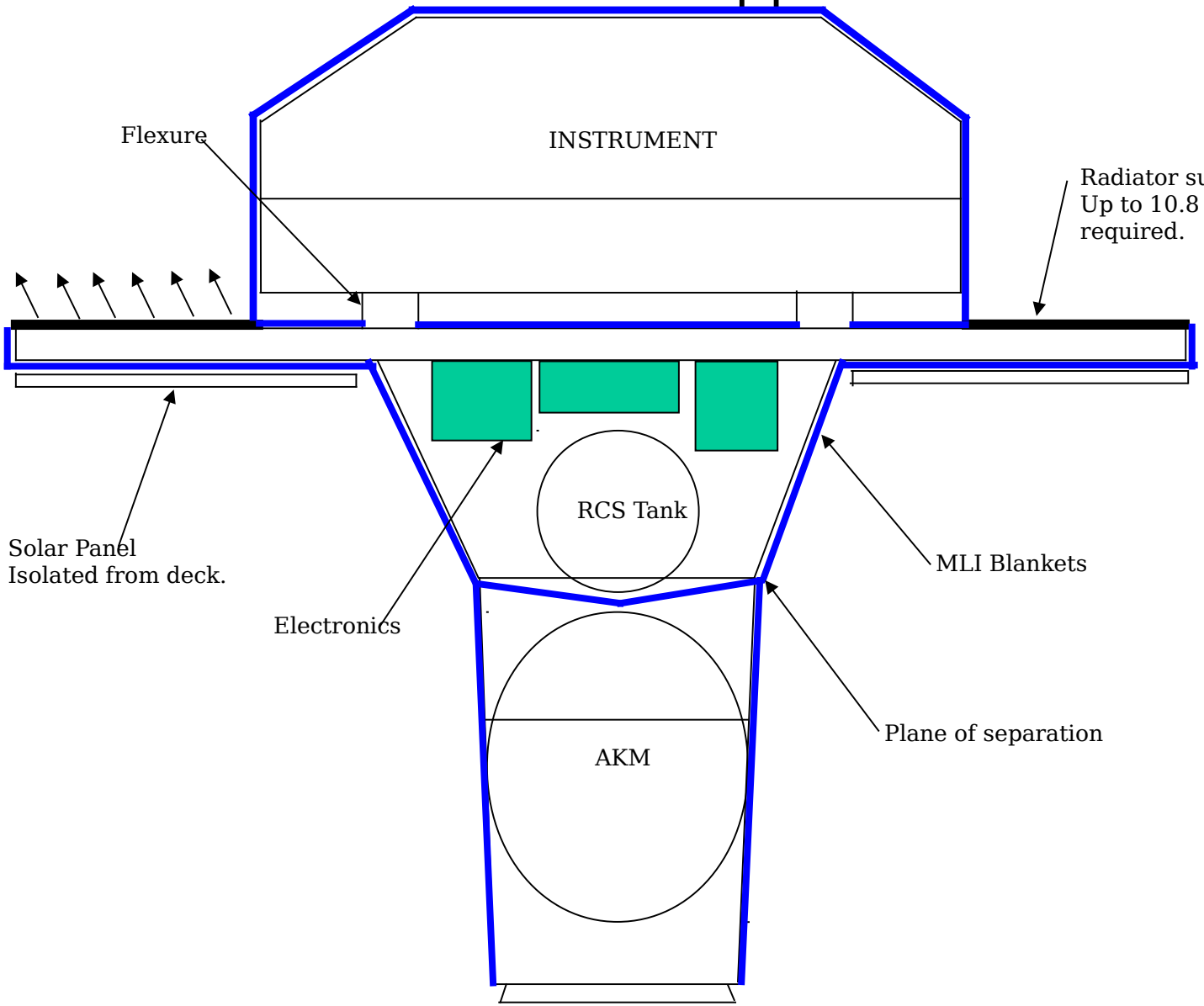
(3 of 4)



Preliminary Design

(4 of 4)

Current Baseline Approach



Preliminary Analysis

(1 of 6)

- Based on 75% Solar Cell Packing Factor:
  - Solar Panels @ 75C with excursion to –50C during eclipse.
    - Recover within 3hr requirement.
    - Temps well within requirements (-80 to 100).
- Current Baseline is 95% Packing Factor:
  - Solar Panels @ 100C with excursion to –45C during eclipse.
    - Still recovers within 3hr requirement.
    - Temperature at upper limit.
  - Need to add solar panel radiator.

Preliminary Analysis

(2 of 6)

- Solar Panel Radiator Trades:

  Add sheet metal radiator to panel
  - About 6 inches tall around circumference.
  - 8 to 10 lbs.

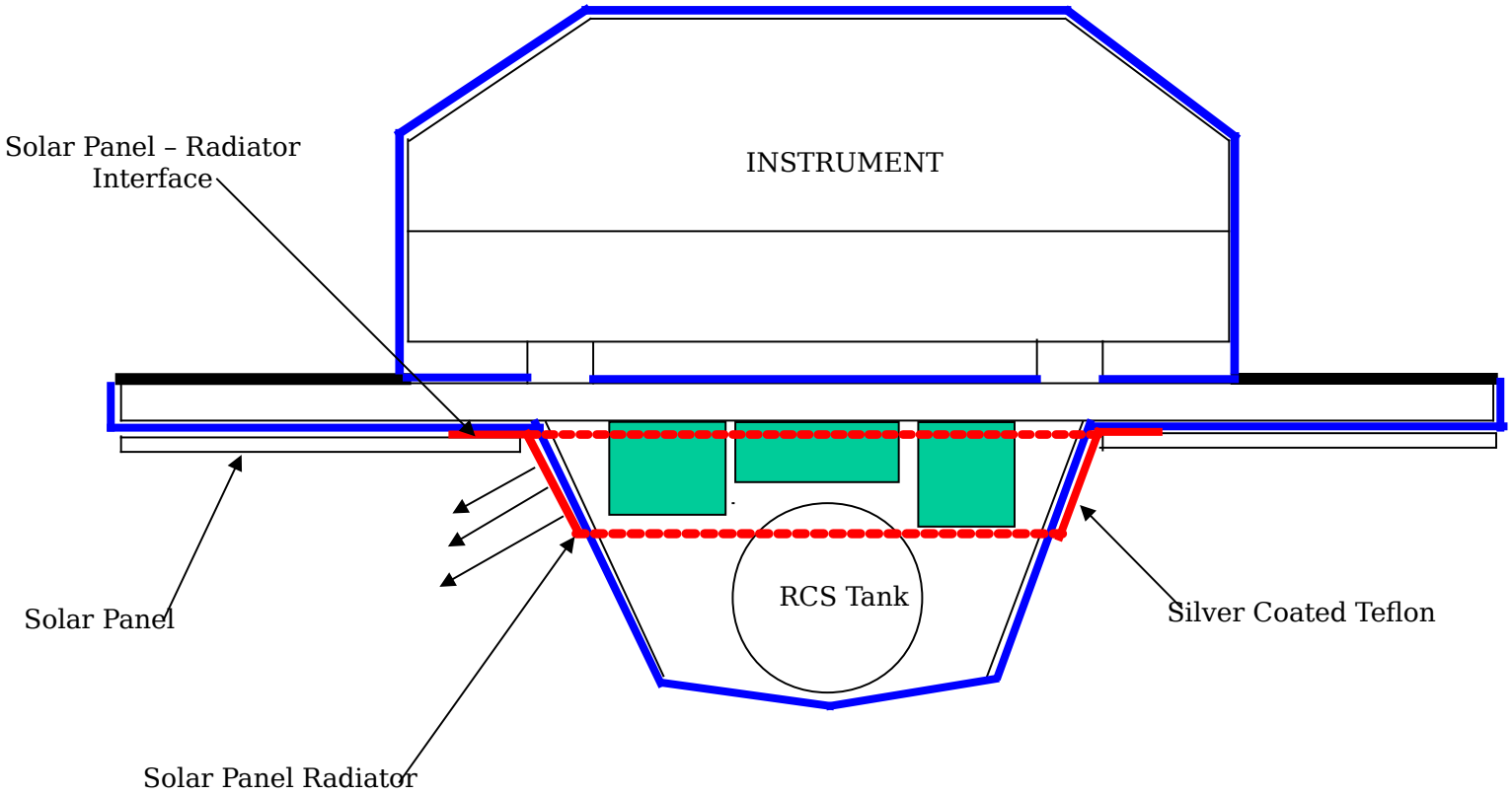
  – Create window through e-deck to space.
    - Radiate from back of panel.
    - Area limited.
      - Need ~5ft^2.

  – Create window through MLI to e-deck.
    - Radiate from back of panel.
    - Complicates Design.
      - Need 5 to 7ft^2 depending on operating temperature.

Preliminary Analysis

(3 of 6)

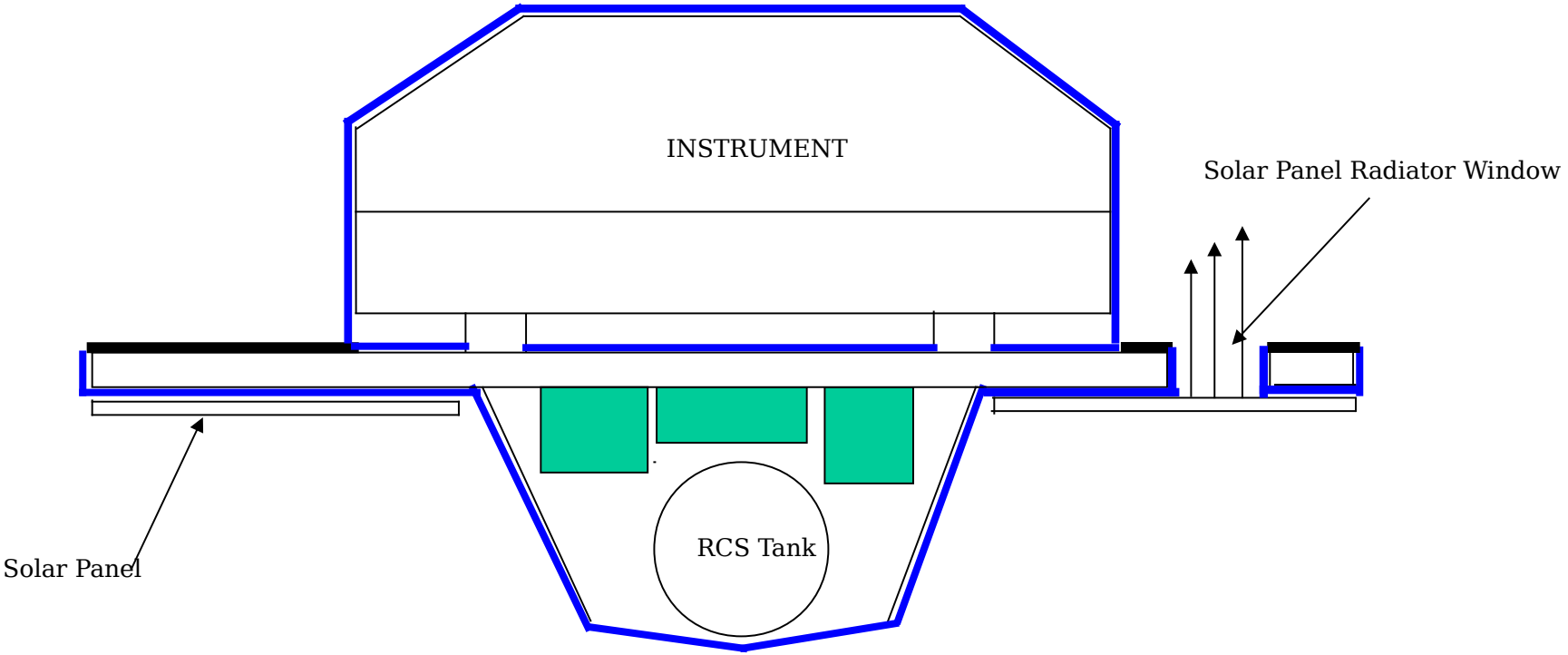
- Bolt on Solar Panel Radiator



Preliminary Analysis

(4 of 6)

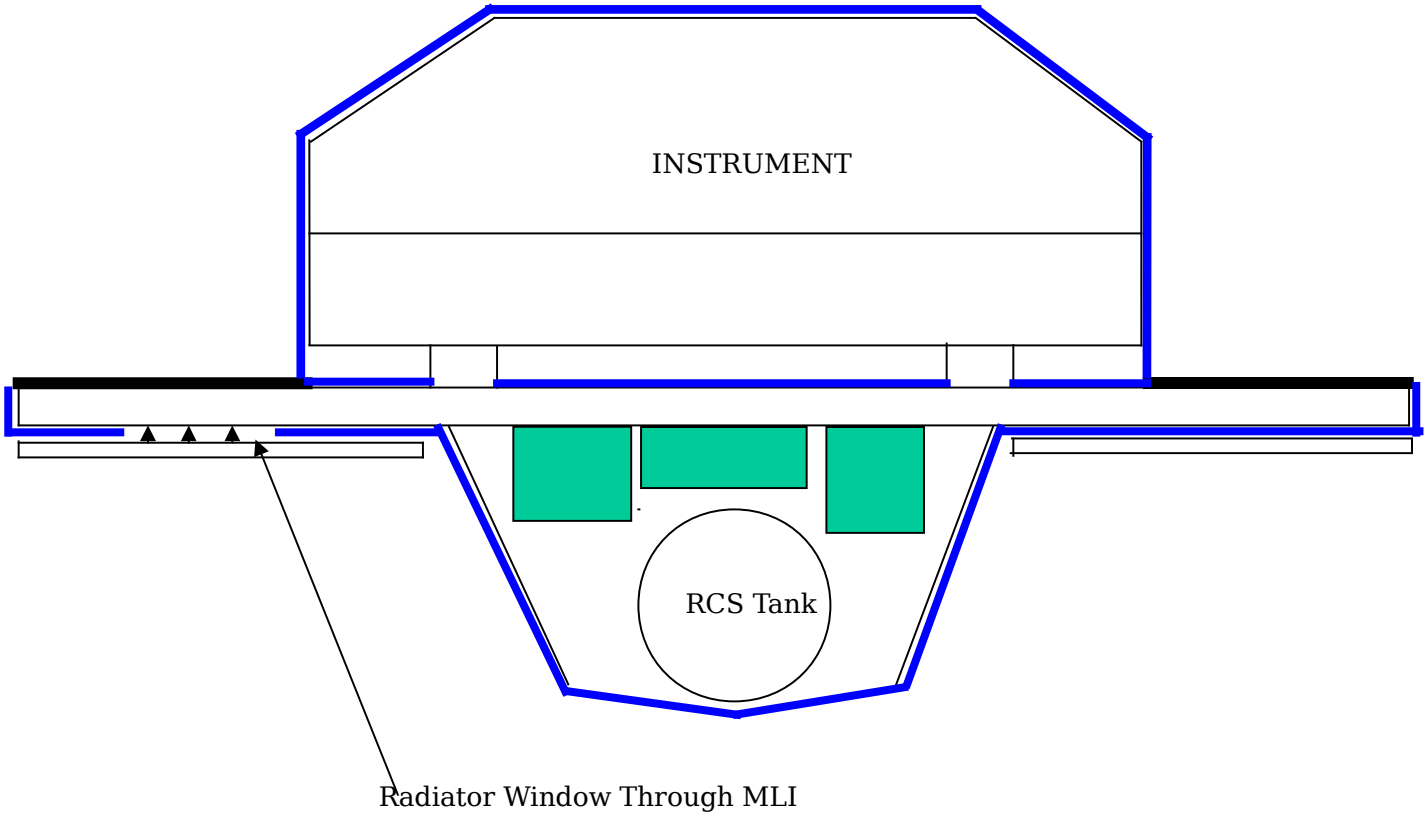
- Radiator Window in E-deck



Preliminary Analysis

(5 of 6)

- Radiator Window To E-deck



Preliminary Analysis
(6 of 6)

- 0 to 40 electronics deck temperature easily achievable with margin.
  - Gradient from boxes to radiator near 10C.

Forward Work - PDR

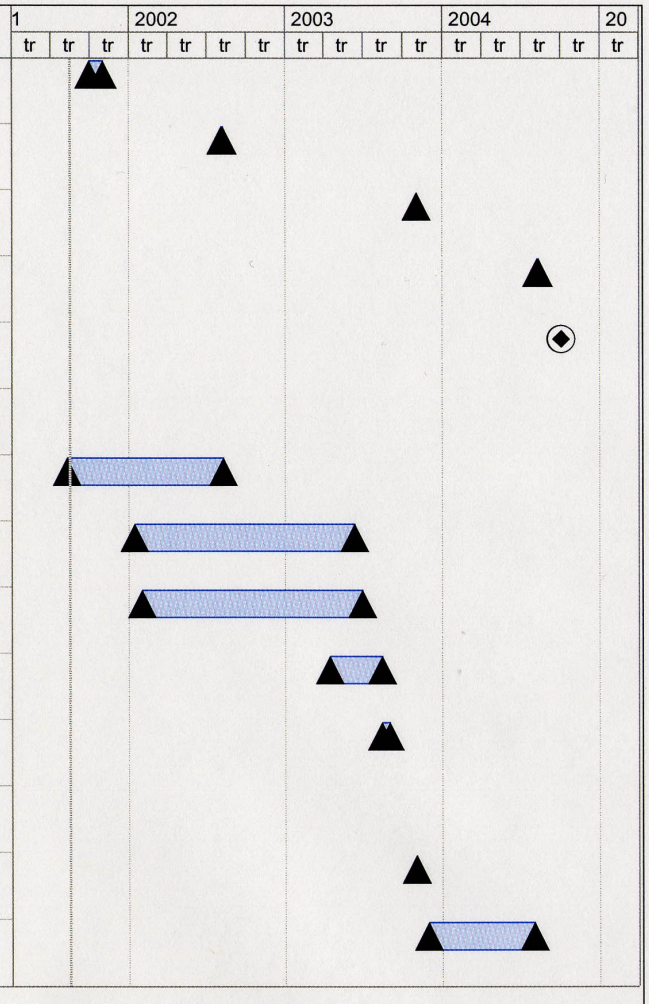
- Trade Studies
- Initial Thermal Model
  - Interface Orbital Temperature Fluctuations
  - Detail External Surface Temperatures
  - Thermal Time Constant
  - Deliver to instrument – Early September
- Optimize Optical Properties – Materials
  - Radiators
  - AKM thermal blankets

Trade Studies

- AKM Jettison Time Frame
  - Conduction path to structure design vs. Immediate Jettison.
    - Engine casing temperature reaches 260C as a result of soak back following burn.
- Battery location/Box layout on Electronics Deck
  - Impacts heater circuit size.
    - Need to optimize Mechanical/Thermal design.
- Radiator Size/Implementation
  - Impacts survival heater circuit.
    - Need to Trade Requirements for Operations vs. Survival Mode.

Top Level Schedule

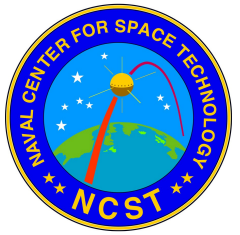
ID	Task Name	Duration	Start	Finish	Predecessors
1	PDR	24 days?	Mon 10/1/01	Thu 11/1/01	
2	CDR	4 days	Mon 8/5/02	Thu 8/8/02	
3	TRR	1 day?	Mon 11/3/03	Mon 11/3/03	
4	SHIP	4 days	Mon 8/9/04	Thu 8/12/04	
5	LAUNCH	1 day?	Mon 10/4/04	Mon 10/4/04	
6					
7	TCS DESIGN / ANALYSIS	261 days?	Fri 8/10/01	Fri 8/9/02	
8	Hardware Procurement	368 days?	Tue 1/15/02	Thu 6/12/03	
9	Blanket Fabrication	367 days?	Fri 2/1/02	Mon 6/30/03	
10	Thermal Integration	88 days?	Wed 4/16/03	Fri 8/15/03	
11	Thermal Design Verification Test	12 days?	Fri 8/15/03	Mon 9/1/03	
12					
13	Spacecraft Complete	1 day?	Mon 11/3/03	Mon 11/3/03	
14	System Level Testing	176 days?	Mon 12/1/03	Mon 8/2/04	



Issues/Concerns

- Electro-Static Discharge
- Solar Panel Temperature


Full-sky Astrometric Mapping Explorer


NAVAL CENTER FOR SPACE TECHNOLOGY
NCST

Backup

Derived Requirements

- Temperature (ºC)

	Operational	Non-Operational
– Battery	0 to 30	0 to 30
– Thruster Valves	5 to 40	5 to 40
– RCS Components	5 to 40	5 to 40
– Structure	-10 to 50	-20 to 60
– Elect. Deck Gradient	10	10
– Instrument Interface	0 to 40	0 to 40
– Solar array	-80 to 100	-100 to 125
– Star Cameras	-20 to 40	-30 to 50
– AKM	< 370	4 to 32
– Motors	-40 to 80	-40 to 80
– Design Margin Goal	5	5

Derived Requirements (Cont.)

- Environments
  - Solar Flux 415 to 444 BTU/HR-sqft
  - Albedo0.21 to 0.30
  - Earth IR 74 to 87 BTU/HR-sqft
  - Eclipse Duration 71 min/day @20 days max
  - Launch Vehicle 70F at Liftoff
    1135 W/m^2 at Fairing Jettison
    148F Peak Internal Fairing Temperature

Derived Requirements (Cont.)

- Power (Preliminary)

(Watts)	Operational	Survival	Launch
– Electronics	173	122	103
– Heaters	65	95	25

  - Heater Design Margin
    - Sized for 24 volts – Nominal Voltage is 30 ± 6 volts.

Heater Circuits

Heater Circuit Description	Circuit Quantity	Each Watts	Total Watts	Comments
The following circuits on critical bus				**TBR**
Star Camera	2	5	10	
Magnetometer	2	3	6	
Thrusters (Valve)	12	1.5	18	
Sun Sensors	4	3	12	
RCS Lines/components	1	20	20	Survival Only - Depends on implimentation.
RCS Tank	1	20	20	
Battery	1	TBR	TBR	Depends on implimentation - Power currently reflected in E-decl
Relay in circuit - Critical bus not required				**TBR**
Trim Area motors	3	3	9	Survival Only
Trim Tab Motors	3	3	9	Survival Only
Electronics Deck	1	65	65	Survival Only **TBR - Dependent on placement of boxes**
			169	**Total**
Commanded Circuits				
Thrusters (CAT-BED)	12	3	36	
Contingency Only Circuits				
AKM	1	60	60	**May or May not be operated prior to AKM firing.**
			265	**Total (All Circuits)**
			86	**Operational Total**
			64.5	**75% duty cycle**

Derived Requirements (Cont.)

- Electronics Box Environmental Testing
  - Typical Components mounted on Electronics Deck

- Operational 0 to 40
- Acceptance Test -5 to 45
- Protoflight Test -10 to 50
- Qualification Test -15 to 55

Derived Requirements (Cont.)

- Materials
  - All components/materials shall have certification/lot traceability.
  - Environmental Testing will be in Accordance With NCST-TP-FM001, FAME Test Plan.
  - MLI Blankets
    - Meet requirements for Outgassing
      - TML < 1.0% CVCM < 0.1%
    - Redundantly grounded with no single layer exceeding 50 ohms to any point on structure.
  - Applied Optical Surfaces
    - Metalized tapes/OSR's provided with some TBD path to ground.
  - Optical Property Variations shall be minimized.
  - Optical Property Degradation shall be understood.

Failure Modes

- Thermostats
  - Fail open – 2 switches per circuit wired in parallel.
- Heaters
  - Multiple elements wired in parallel.
- Thermistors
  - Sufficient numbers in key locations.

Blanket Construction

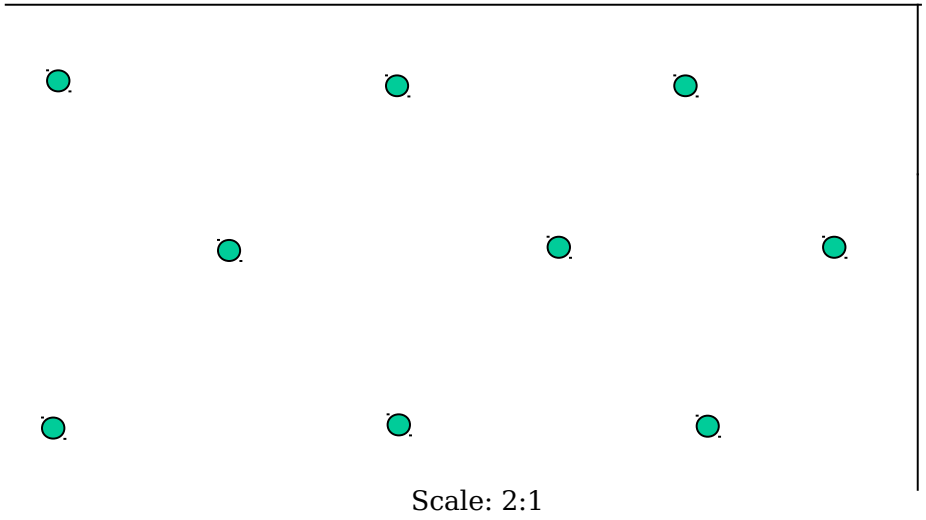
(1 of 6)

- Stray Light Prevention
  - Assumptions:
    - All blankets are designed to vent inboard.
    - All interior layers are provided either perforated or loose meshed.
    - Vent paths are provided from the blankets, either into the spacecraft or through the small voids (about 0.5 inches spaced 6 inches apart) in the tape holding the blankets to the structure.

Blanket Construction

(2 of 6)

- Stray Light Prevention

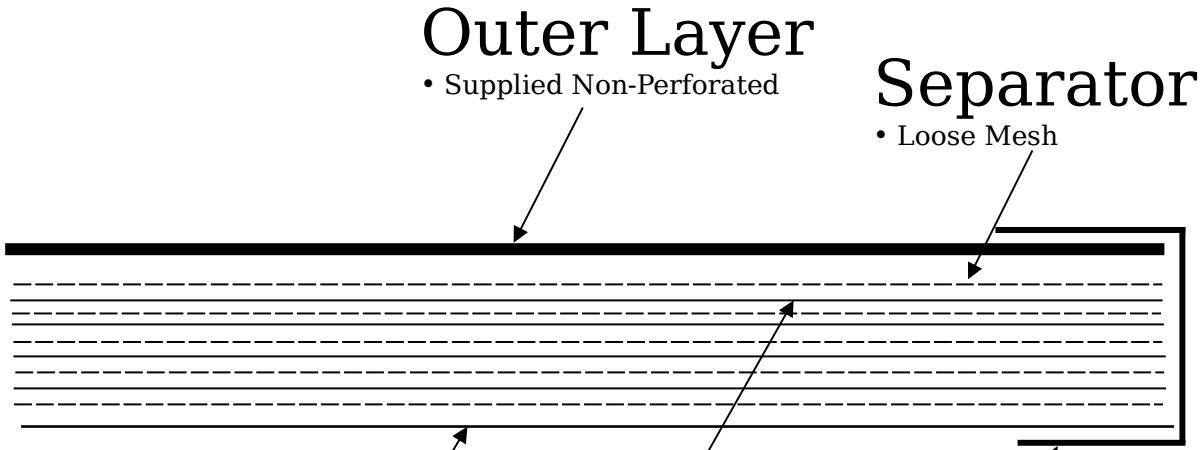


Typical Reflector Layer Perforation
Dunmore Pattern #101.

Blanket Construction

(3 of 6)

- Stray Light Prevention



Outer Layer
- Supplied Non-Perforated

Separator Layer
- Loose Mesh

Inner Layer
- Supplied Perforated

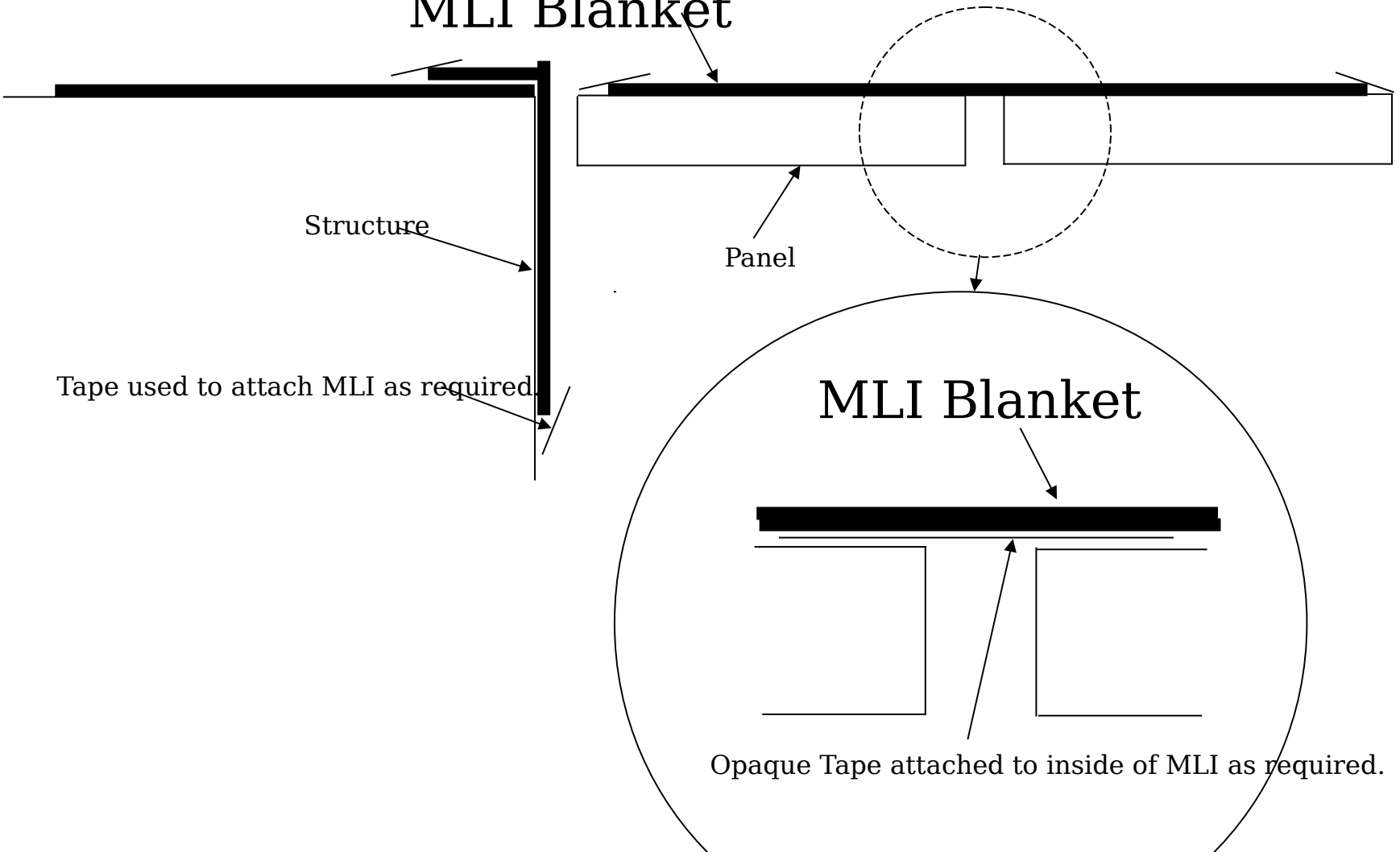
Reflector Layer
- Supplied Perforated

Tape
- 100% Continuous coverage of blanket edge.
- Opaque material - Black Kapton.

Blanket Construction

(4 of 6)

- Stray Light Prevention



Blanket Construction

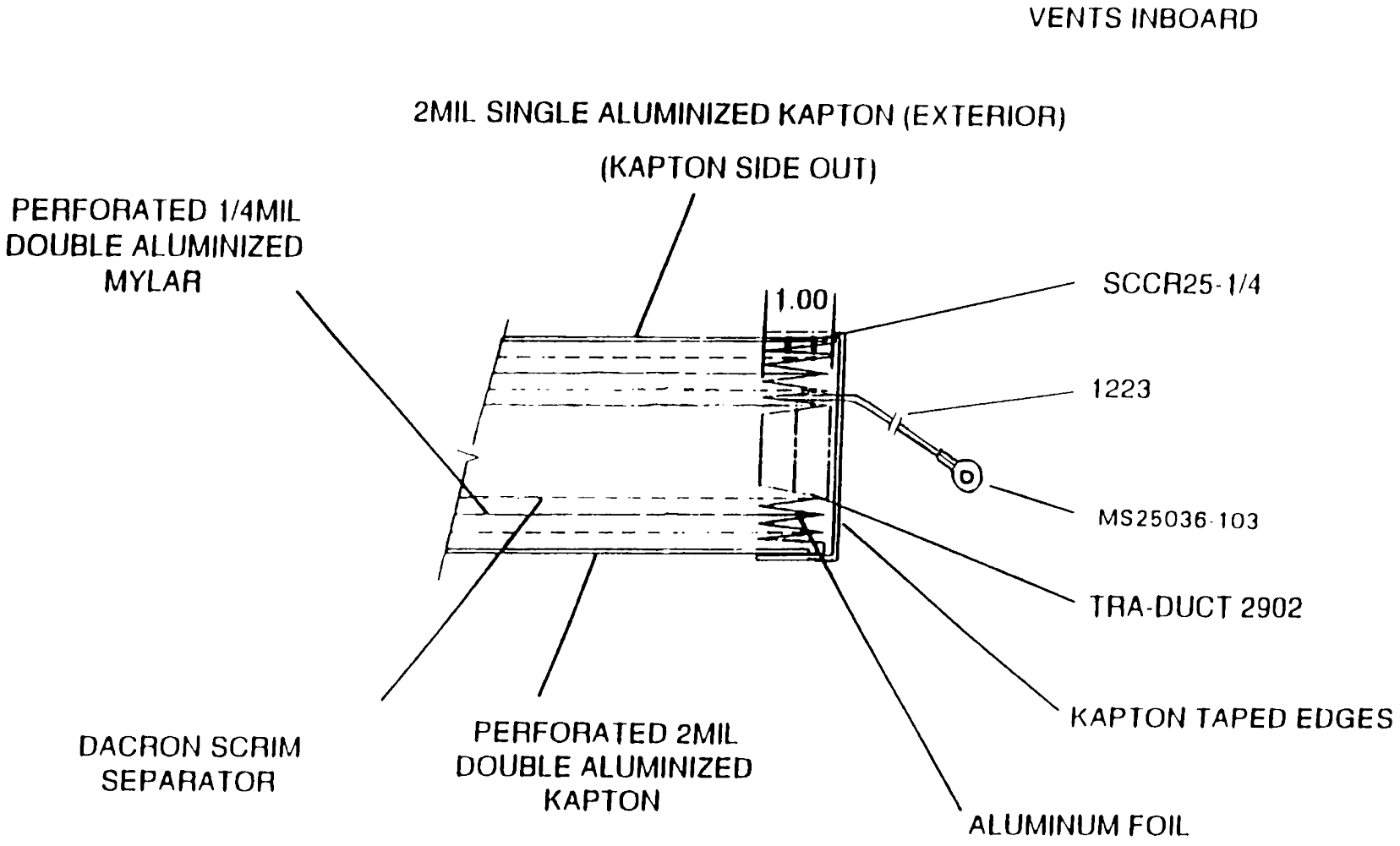
(5 of 6)

- Stray Light Prevention
  - Conclusion
    - No path for light to travel.
      - All blanket edges closed out with opaque tape.
      - Any exposed interior layers covered with opaque tape.

Blanket Construction

(6 of 6)

- Blanket grounding



Contamination

- Plume Analysis
- Venting Analysis
- Material Selection